

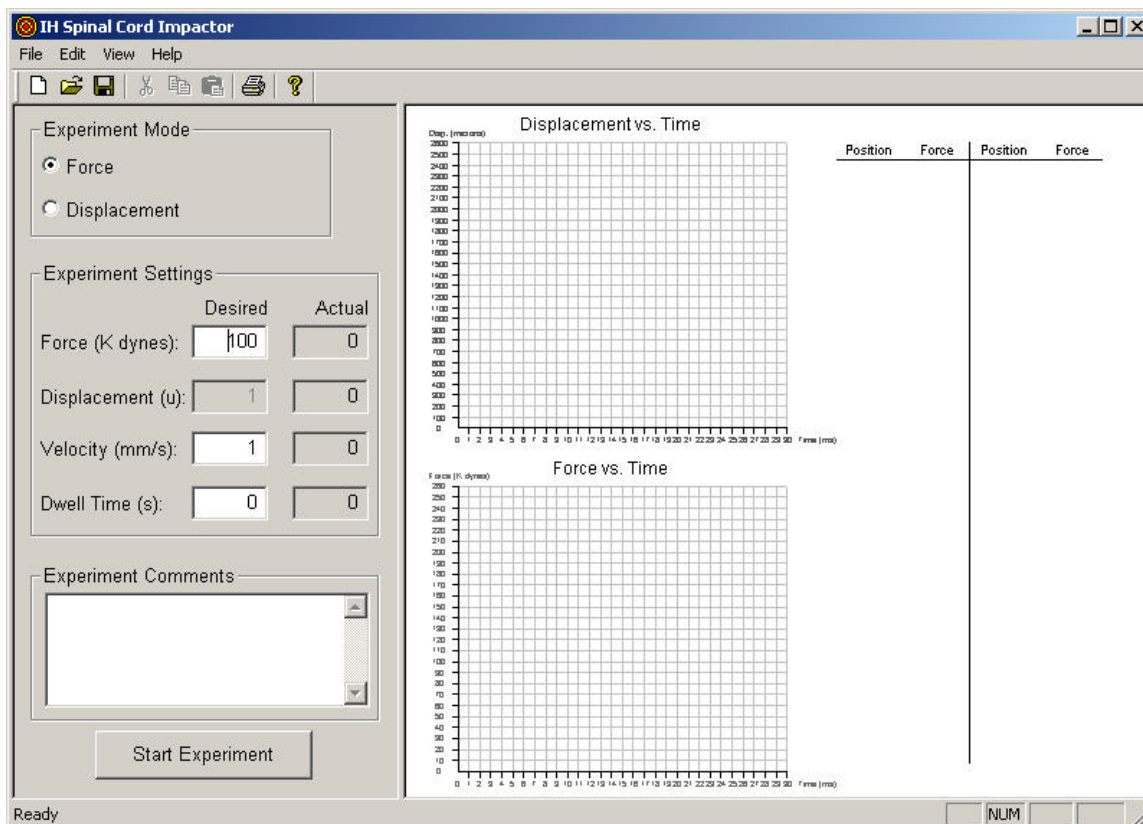
IH SPINAL CORD IMPACTOR

by

Precision Systems & Instrumentation

USER'S MANUAL

10/2002



Site Requirements for the PSI - IH Impactor 2002

A suitable environment is important for the proper optimal performance of the IH Impactor 2002.

Power Considerations

The IH Impactor accepts a line voltage in the range of 110-115 V with a line frequency of 60 Hz. Consequently, there is no voltage selector in the rear of the instrument. It is recommended that the instrument be connected to a power surge protected power strip rated at 1200 or greater joules. This will protect the sensitive computerized circuitry in the control against damage from harmful power surges and spikes. Shock hazard or damage to the IH Impactor may result if the IH Impactor is connected to a line voltage higher than specified.

Never operate the IH Impactor from a power outlet that has no ground connection. Never use a power cord other than that supplied with the IH Impactor.

Never use cables other than those supplied with the IH Impactor to ensure proper functionality.

Bench space

The IH Impactor dimensions and weight allow for maximum flexibility to fit almost any desk or laboratory bench. The impacting portion of the instrumentation **should not** be placed on the control unit during operation. It is recommended that the control unit be placed such that it can achieve adequate ventilation during operation. Do not block the ventilation slots on the top of the control unit. It is also recommended that if a laptop computer is running the provided software, it **should not** be placed on the control unit during operation.

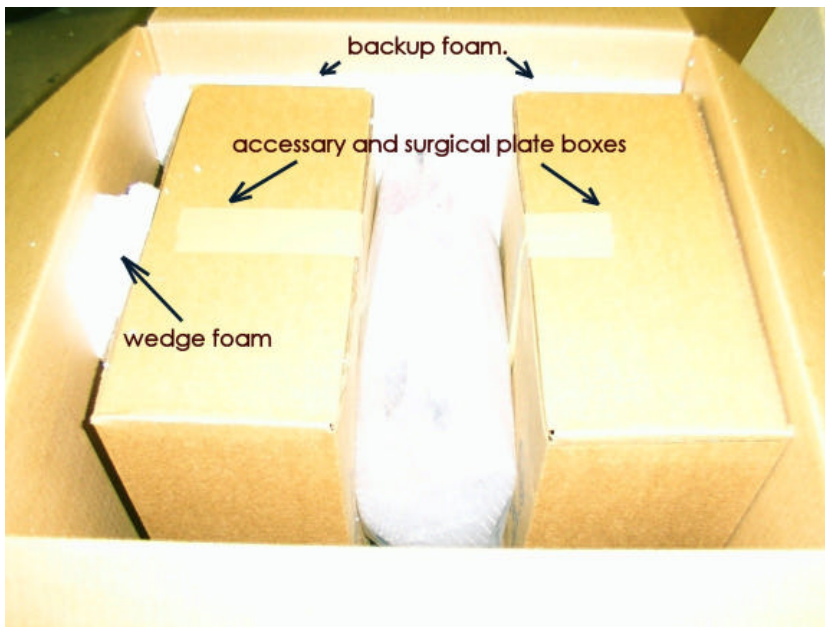
Environment

The IH Impactor will work within temperatures and humidity that are specified by the computer the instrument is interfaced with. For practical purposes this would be within the range of 65°F to 85°F and humidity 40% to 95%.

In order to function properly, do not place the IH Impactor on a vibrating surface or near vibrating objects.

Unpacking the PSI - IH Impactor

Upon receipt of your IH Impactor, control unit and cables, inspect the shipping containers for any signs of damage. If containers or cushioning material are damaged, save them until the contents have been checked for completeness and the impactor and control unit have been mechanically and electrically checked. If the shipping container or cushion material is damaged, notify the carrier as well as PSI. Save the shipping material for the carrier's inspection.



1. Impactor will be packed similar to the picture shown to the left. The impactor itself will be wrapped and packed in foam. The accessories are packaged in the accompanying boxes.



2. To unpack, first remove the accessory boxes and foam padding.



3. Remove the Impactor from the shipping box and set aside. Remove all the packing material and wrapping.



4. Finally, remove the control unit from its box. It will be wrapped in bubble wrap as shown. Remove the padding for setup.

Setting Up the PSI - IH Impactor 2002

You should have the following items

1. Impactor (with force, position, and motor cables) (1 each)
2. Control unit (1 each)
3. AC power cable for control unit (1 each)
4. RS232-Din15 computer interface cable (serial cable) (1 each)
5. Experimental table with attached support arms and flexible ball joints (1 each)
6. Adson spinal cord stabilizing forceps (2 each)
7. User software CD (1 each)
8. Impactor tip – rat (1 each)
9. Impactor tip – mouse (1 each)
10. User Manual (This Document) (1 each)

Set up the PSI - IH Impactor and Control unit

When fully assembled the IH Impactor should look similar to Figure 2.

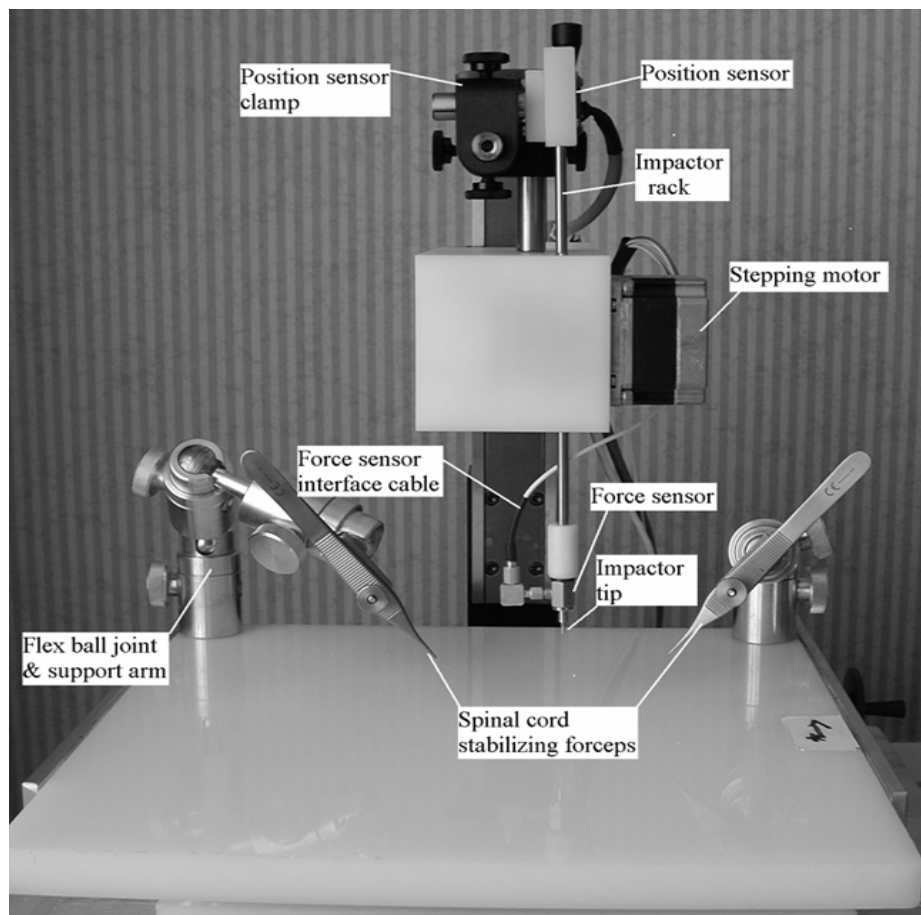


Figure 2 Assembled Impactor

When properly assembled, the IH Impactor should appear similar to the above picture. The removable experimental table has two permanently mounted support arms with flexible ball joints. These arms hold the Adson stabilizing forceps. The experimental animal will be positioned between these two forceps with the exposed spinal cord directly beneath the impactor tip and force sensor. The stepping motor located on the right side of the IH Impactor drives the impactor rack downwards. On one end of the impactor rack is the force sensor and impactor tip, while on the other end is an encoder strip that activates the position sensor held in place by the position sensor clamp. The experimental table, on which the animal is placed, can be carefully positioned under the impactor tip, prior to injury, with the aid of two horizontal control wheels. The vertical height of the impactor tip can be initially adjusted with the vertical hand wheel.

One of the most important components of the IH Impactor is the **position sensor**. This sensor is attached to a clamping mechanism that ultimately attaches to a small **stand post** on the top of the impactor. Carefully remove the bubble wrap on the sensor and clamping mechanism. One portion of the clamping mechanism will be attached to a stand post as shown in Figure 3. Care must be taken not to damage the **encoder strip** that is attached to the top portion of the **impactor rack**.

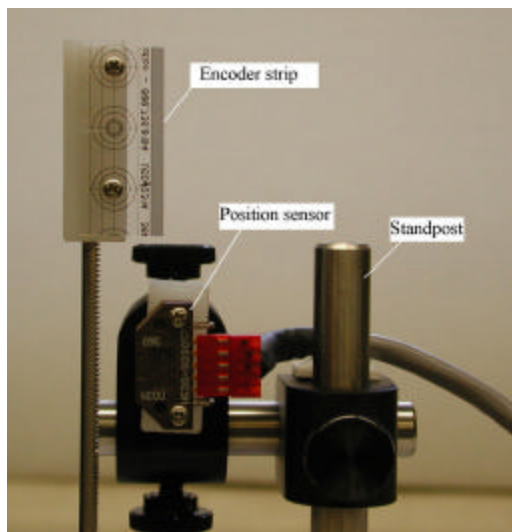


Figure 3 Position Sensor Assembly

Make sure that the encoder strip is properly aligned. To assure proper alignment, move the impactor rack with encoder strip attached to a height such that the entire encoder strip is above the slot in the position sensor. Move the clamping mechanism of the position sensor to a position midway on the stand post and lightly tighten (It may already be in that position). Slowly move the impactor rack and encoder strip down towards the slot in the position sensor. It is important that the rack and encoder strip have sufficient room to move upward and downward and do not bind to any part of the impactor. There should be some resistance

in movement of the impactor rack since it is controlled by a gear attached to the stepping motor on the side of the impactor. The encoder strip should be in a position such that the position sensor lies midway between the top and bottom of the encoder strip as shown in Figure 4. It is very important during the final alignment that the encoder strip lies flush against the side of the position sensor.

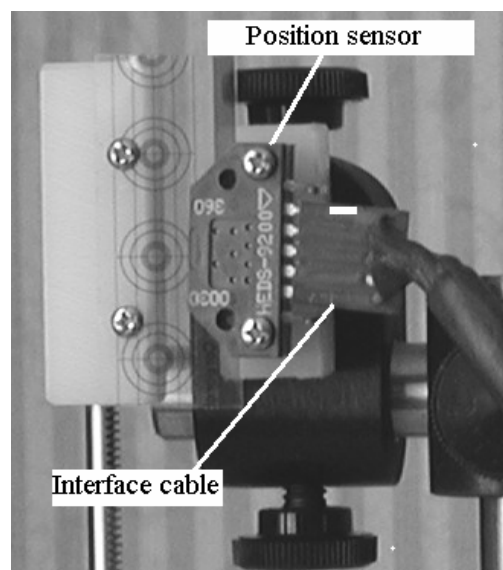


Figure 4 Encoder Strip Properly Positioned

The control unit (Figure 5) is the interface between the IH Impactor and the computer running the IH Impactor software. The rear of the control unit has several different connectors. It is important that the different components of the impactor be securely connected for proper operation. The connectors on the back of the control unit are all different ensuring proper connection of the different cables.



Figure 5 Back of the Control Unit

Check to see that the position sensor interface cable is completely connected to the 5 prong connector on the position sensor (Figure 6). Connect the other end of the interface cable to the rear of the control unit at the connector marked "Position Sensor" (Figure 5).

Connect the stepping motor interface cable to the IH Impactor control unit. The interface cable is already attached to the stepping motor (Figure 6). The opposite end of the cable should be attached to the rear of the control unit at the connector marked "Motor Control" (Figure 5).

Connect the force sensor interface cable to the IH Impactor control unit (Figure 5) at the position marked "Force Sensor." The interface cable is already attached to the force sensor.

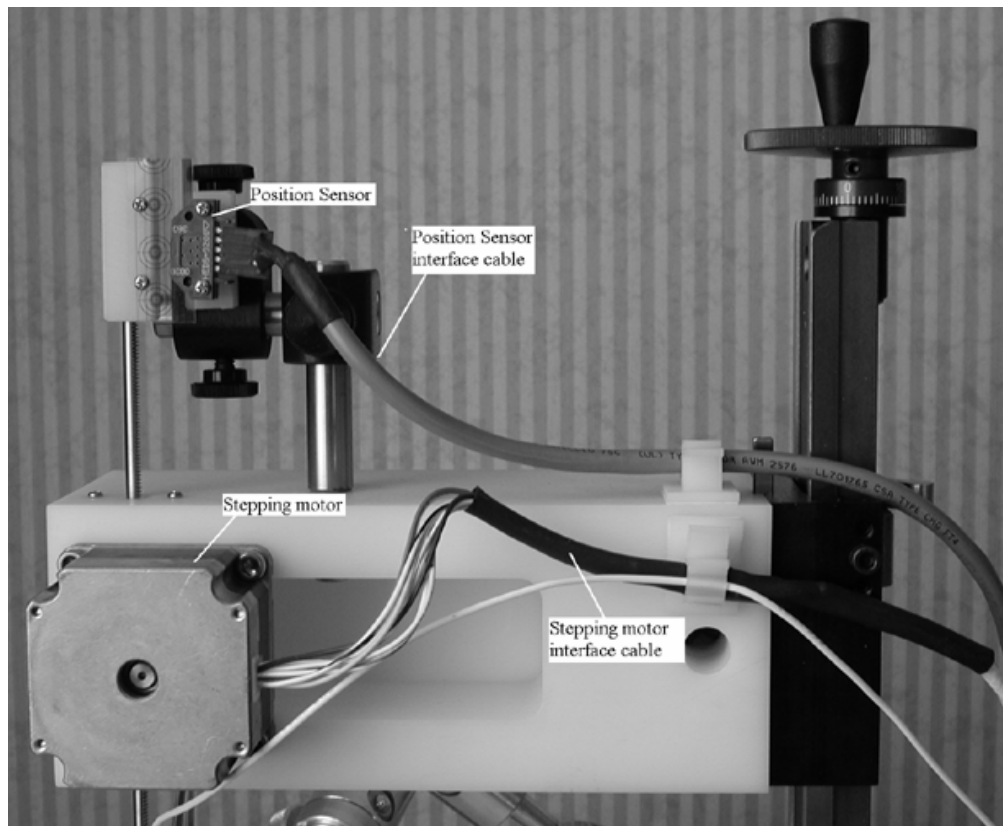


FIGURE 6 Side View of Impactor Assembly with Cables Connected

Installing IH Impactor Software

Computer and monitor: 486/66 or higher PC (Pentium recommended) with at least 64 MB RAM, a hard disk with 8 MB of free disk space, a double-speed CD-ROM drive (4-speed recommended) and a video board and monitor capable of running 256-color. The system should be running Windows 98, 2000, XP, or NT 4.0.

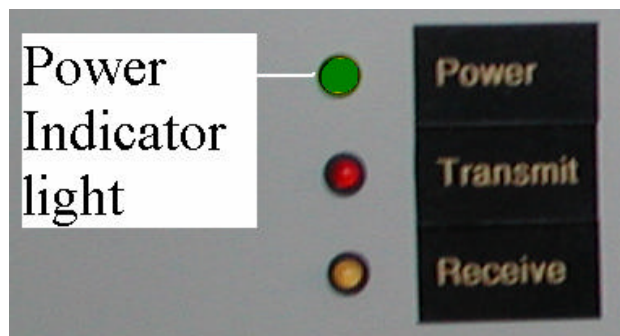
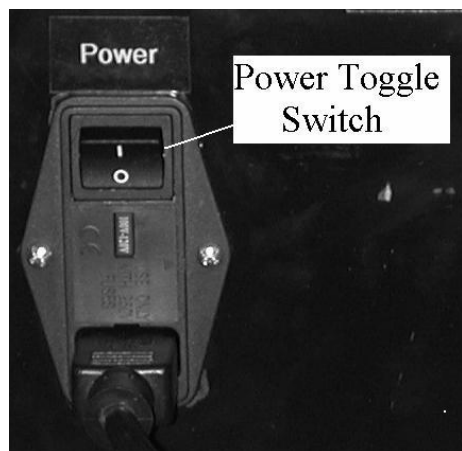
The software that enables the user to control the movement of the impactor rack by the stepping motor is contained on the CD. Insert the IH Impactor CD-ROM. From the Start menu, choose RUN, and then Browse to open the Install program on the IH Impactor CD-ROM. Following the onscreen instruction of the self-extracting file.

Once the program installation is complete, the shortcut icon will appear on the desk top.



Running the IH Impactor Software

Before launching the IH Impactor software program, **turn on the power to the control unit** with the power toggle switch on the back of the control unit.



A power indicator light on the front of the control unit will glow green, indicating that sufficient power has been supplied to the control unit. If the power indicator light does not come on, turn the unit off and check to be sure the control unit is plugged into an appropriate socket of the power strip. Also make sure the other end of the power cord completely engages the AC power connector on the back of the control unit. Use the power toggle switch again to supply power to the control unit.

If the power light still does not glow green, call technical support.

Once the power indicator light on the front of the control unit glows green, launch the IH Impactor software by double-clicking on the icon now located on the computer desktop.



PSI Spinal
Impactor

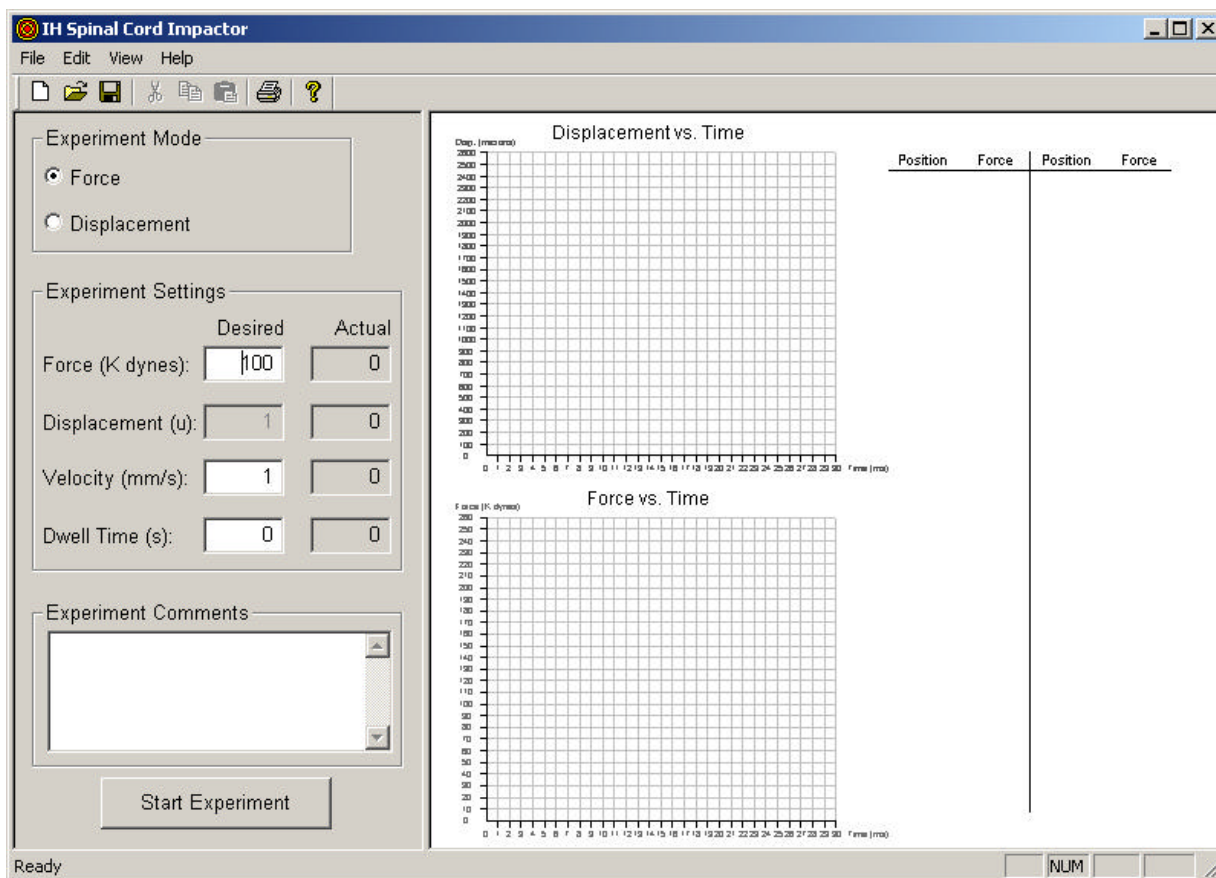
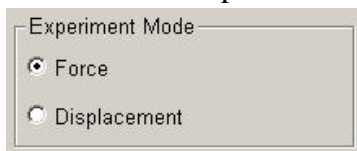


Figure 7 The PSI IH Spinal Cord Impactor software. This is the initial screen from which the experiments will be setup and displayed.

The IH Impactor software is composed of two main frames. The left frame is for setting up all the experiment variables, storing comments, and running the experiment. The right frame contains all the post-experiment data displayed as a force graph, a displacement graph, and a chart of the raw values from the control unit.

The Setup (Left) Frame

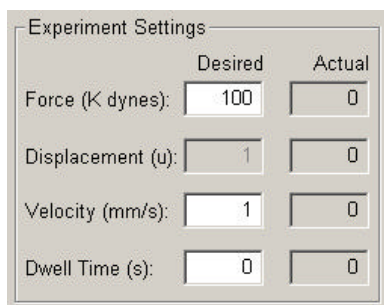
This frame is where the experiment is setup and run from. When running an experiment, first choose which impact mode you want to use. The default is to run a force experiment. **(At the**



present time, the displacement experiment option is unavailable in the current software release. Look to the PSI website for future updates). When running a force experiment, the force input field is highlighted and the displacement is made unavailable (Figure 8). Clicking on Displacement Experiment will

highlight the displacement input field and make the force input field unavailable. The velocity field while active currently has no bearing in how the experiment is run. This can be left to the default value. The dwell time is an alterable value though. Dwell time is defined by the length of time the impactor tip remains at its final displacement following application of a previously defined force. For example, if a 50 kdyn force is applied and the displacement is 475 microns, a setting of 5 in the dwell time field would instruct the instrument to hold the impactor tip at that

displacement for 5 seconds before withdrawing. **The amount of force applied to the cord will NOT remain at 50 kdyns because of spinal cord tissue dynamics.** The default value for dwell



	Desired	Actual
Force (K dynes):	100	0
Displacement (u):	1	0
Velocity (mm/s):	1	0
Dwell Time (s):	0	0

FIGURE 8 Experiment Settings Setup Fields

time is zero, indicating that the impactor tip will withdrawal immediately after reaching the desired impacting force.

Currently the **maximum dwell time is 10 minutes.**

Experimenters requiring longer dwell times should contact the manufacturer for a software modification. Next to each of the Desired Value entry fields are Actual Value fields. These are not user modifiable fields, but rather they report back the actual experimentally acquired values after an impact. The Experiment Comments Box is available to make any comments you would like to save along with the experiment. In addition to you own comments, the software will automatically log the date and time of experiments in this box. **All experiment comments should be**

made after the impact. Prior to each impact the comments box is cleared to run the new experiment. Finally, the setup frame contains the “Start Experiment” button. When all fields are set and the animal is in position, this will begin the experiment. After pressing it, a verify window will open to ensure you want to proceed with the experiment. This is a precaution against accidentally pressing the button.

The Experiment Data (Right) Frame

This frame is where all the data collected during an experiment is displayed. It consists of the displacement vs. time graph, the force vs. time graph, and a chart listing the raw displacement and force values received from the control unit. Discussion and interpretation of each of these three elements can be found in the post experiment section below.

Conducting an Experiment

This section covers a detail run of an impact experiment, start to finish.

Selecting the appropriate impactor tip

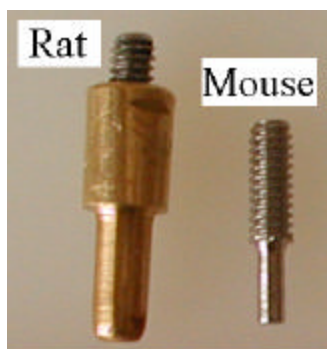


FIGURE 9
Impactor Tips

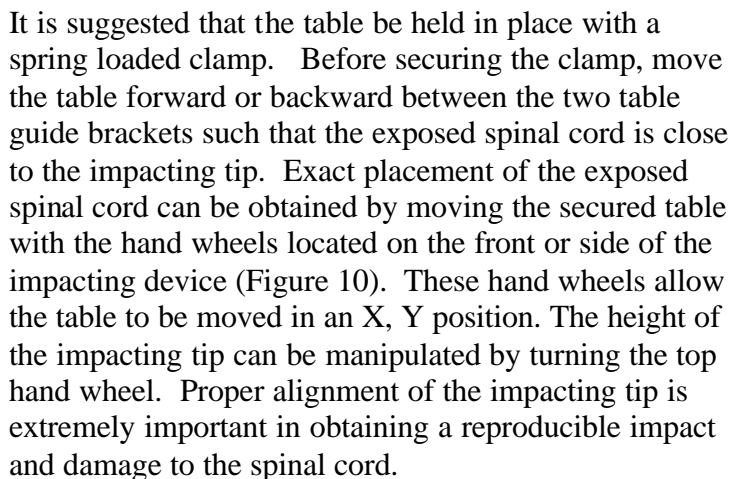
The IH Impactor is supplied with two different impacting tips. The larger tip has a diameter of 2.5 mm and is designed for use with larger animals such as rats. The smaller tip has a diameter of 1.25 mm and is designed for use with smaller animals such as mice. Each tip has an end with screw type threads and an end that is tapered and smooth. The threaded portion of the tip screws into the bottom of the **force sensor** as shown in Figure 2. When changing impactor tips, it is extremely important to only **HAND TIGHTEN** each tip onto the force sensor. It is unnecessary to use tools for this purpose since it may cause serious damage to the force sensor. Tips may be removed between experiments for sterilization purposes. Alternatively, additional tips may be purchased from the manufacturer. Depending

upon the user's application, one of the two different sizes of impactor tip should be threaded into the force sensor.

Suggested force range values: Rat - values between 100 and 200 kdyn
Mouse – values between 30 and 70 K kdyn

Once the settings are entered, it is recommended to do an air impact to test the correct setup of the machine. In an air impact, the displacement graph should be plotted, the force graph should be near zero (since there was no force of impact in air), and the chart should be filled in with raw values.

The experimental table contains the moveable arms and Adson forceps used to stabilize the spinal column prior to injury. The table can be removed from the IH Impactor by sliding it forward away from the vertical column supporting the impacting motorized mechanism. This provides easy accessibility to the flex ball joints and support arms and to the Adson forceps. Once the experimental animal has been properly positioned, the experimental table can be positioned on the IH Impactor. Two table guide brackets help stabilize the table.

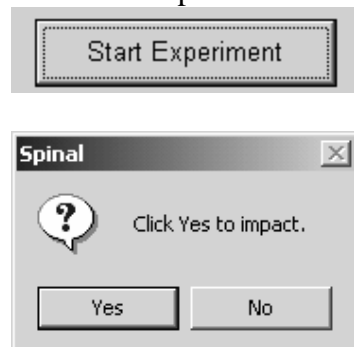


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It is recommended that the impacting tip be lowered to within a few mm of the exposed cord and then by viewing the location from several different angles, realigning the tip. It is not necessary, and highly recommended that the impacting tip **NOT TOUCH** the exposed cord prior to the impact injury. Once the proper alignment has been successfully obtained, the impacting tip should be raised to approximately 4-5 mm above the exposed cord. The impacting tip attached to the rack can move a total distance of 8 mm. Be careful to ensure that the encoder strip is still located within the position sensor with a portion crossing the midline of the sensor. If the encoder strip is not in the position sensor, or a portion of it does not begin in the middle of the sensor, incorrect displacement values will be reported.

Initiation of the injury

Click the “Start Experiment” button found in the setup frame to initiate the injury sequence. Before an impact is made the instrument will self-calibrate. This is seen by a little twitch in the



impacting arm as it moves up and then back to the original starting position. The confirmation window will also appear. If all of the experimental conditions are properly set (i.e. alignment of impacting tip, amount of force to be applied to exposed spinal cord and dwell time defined), click the “Yes” button. The stepping motor will immediately activate and the rack will move the impacting tip onto the exposed spinal cord. The impacting tip will then retract to the start position after the desired dwell time (immediately if dwell is set to zero).

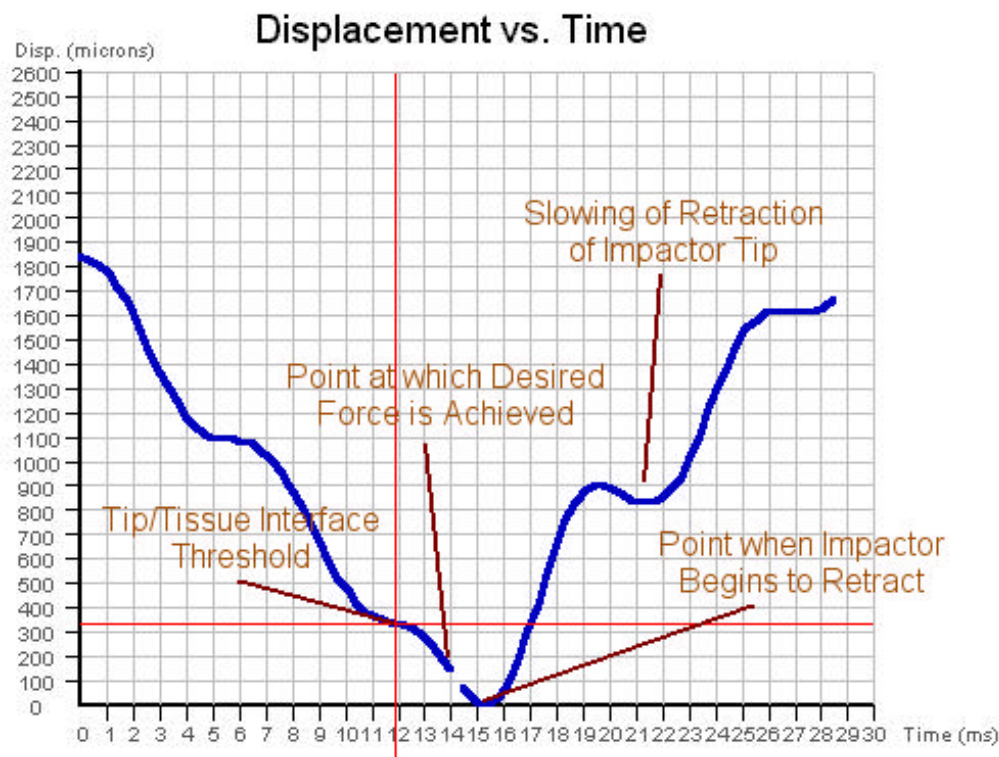
Displaying and Interpreting Experiment Data

On completion of the injury cycle, the data gathered by the control unit will be sent to the software which will update the actual values in the “Experiment Settings” portion of the setup frame (Figure 11), the displacement graph will be drawn (Figure 12), the force graph will be drawn (Figure 13), and the raw value chart will be filled in (Figure 14). In the example shown

Experiment Settings		
	Desired	Actual
Force (K dynes):	100	103
Displacement (u):	1	617
Velocity (mm/s):	1	124
Dwell Time (s):	0	0

here, the instrument was set to use 100 kdyn of force, with the actual force applied being 103 kdyn. The impactor tip displaced the cord by 617 μ m at a velocity of 0.124 m/sec. The impactor tip did not dwell for any appreciable amount of time.

FIGURE 11 Experiment Settings with Actual Values

Displacement vs. Time graph**FIGURE 12** Displacement vs. Time Graph with Key Points Labeled

The Displacement graph plots the displacement of the tip relative to its farthest point in the tissue, in microns, against the time taken for the tip to drive down, impact the tissue, and retract, measured in milliseconds. The graph is always zeroed on the displacement-axis at the lowest graph point, that point being where the tip is furthest into the tissue. This is, therefore, also the point where the tip begins to retract. The point where the tip starts (0ms) is shown as the highest displacement. This is the distance down the tip traveled during the impact. The graph is inverted like this to correspond with the physical motion of the tip as an impact occurs. Two red lines are also struck on the graph. The vertical red line represents the time at which the tip impacted tissue. The horizontal red line indicates the displacement of the tip into the tissue. To summarize, the graph is read in a manner to correspond with the motion of the tip as it travels down from and back to its starting position. The lowest point on the graph will always be aligned to zero microns and the rest of the points measured relative to this zero reference point. The horizontal red line indicates where along the path of the tip, tissue was encountered, and reads how far into the tissue the tip penetrated. The graph is discontinuous at the point where the desired force is achieved as the impactor tip cannot be instantaneously stopped. The second half, or right half, of the graph shows the motion of the impactor tip after the desired force is achieved. It can be seen that the tip actually moves a bit further into the tissue before the motor is able to overcome its inertia and move it back out. In an experiment where the dwell time is greater than zero, the right half of the curve will not be displayed as it is far out of the range of the graph's time scale. In both the down stroke and up stroke of the tip, non-linear aspects of the curve may be present.

This is seen as the flattening out of the slope of the graph during the impact run. Non-linear areas such as is shown in Figure 12 are typical and do not adversely affect the impact.

Force vs. Time graph

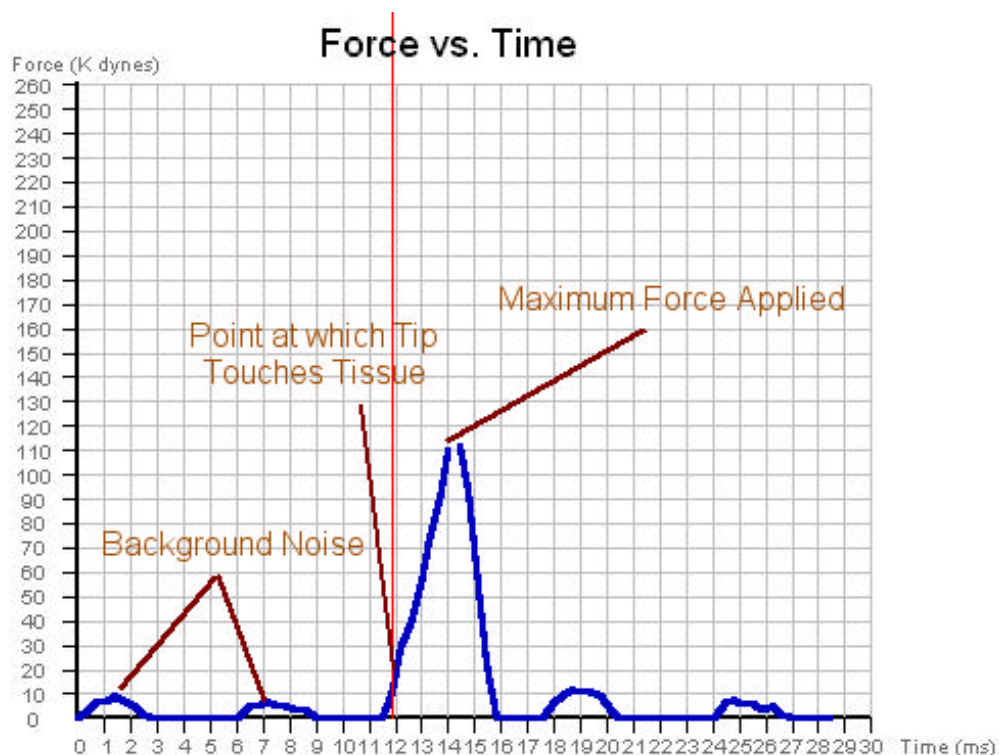


FIGURE 13 Force vs. Time Graph with Key Points Labeled

The Force graph plots the force value, measured in kilodynes, recorded by the force sensor on the impactor tip against the time of the impact experiment. The force graph consists of several small bumps and one larger peak. The small bumps represent background noise the force sensor picks up as it encounters the small resistance of the tip during its drive down and up. The large peak is when the tip impacts the tissue. The tip is considered to be impacting tissue at a force of 20 kdyn. If an impact is ever observed where the force exceeds 20 kdyn before $t = 0$ sec (i.e., impact experiment begins with force above 20 kdyn), then the actual displacement value will read as zero. This can happen if the spinal cord is not secure and moves during impact. At 20 kdyn, a red vertical line will be struck to indicate to the displacement graph above the time at which initial impact occurred. The highest point corresponds to the maximum amount of force applied and should be very close to the desired value. This peak will be more rounded as the tissue impacted becomes softer and more sharp as the tissue becomes harder (such as bone). For high force impacts, the graph will auto-scale the force-axis to maintain readability of the graph. If no impact occurs, the force graph will read zero (or very close to it depending on background noise). It is important not to jostle the tip too much before an impact so as to minimize the amount of oscillation in the force sensor and reduce background noise.

Raw Data Values

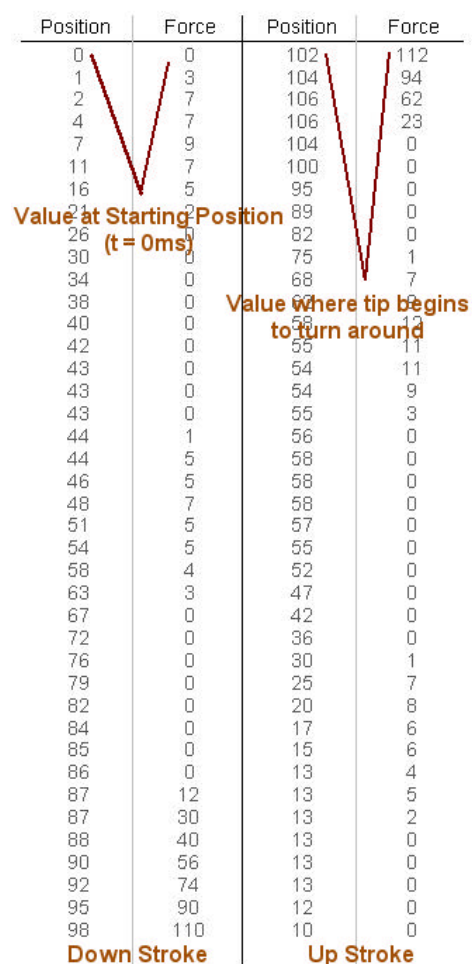


FIGURE 14 Raw Data Values

Experimental Comments

Following completion of the injury cycle, the impactor tip can be raised with the vertical adjustment wheel and the experimental table removed from the guide brackets. After visual inspection of the injury, comments can be recorded in the “Experiment Comments” box. With each experiment run, the software will automatically log the date and time in the “Experiment Comments” box. Comments may be as long as necessary. The comments box will begin to scroll once the available area has been filled.

Additional Software Features

This next section will discuss additional software features. These include saving, printing, and other utilities.

Saving The Experiment Data

To save an experiment data set, click on File->Save or File->Save As. The save works in the same manner as any other Windows program save feature. Saving the experiment will include all the raw data, actual values, and experiment comments in a file with a **.exp** extension. These files are user readable if opened in a standard text editor should the need arise.

Saving the Experiment Data as a Comma Delimited File (Excel Readable)

To save an experiment as a comma delimited file, click on File->Save As Comma Delimited File. Doing this will save the experiment data as a **.csv** file. This file may then be imported into Quatro Pro, Excel, or any other spreadsheet program.

Open Experiment Data File (.exp)

To open a previously saved experiment, click on File->Open. The open works in the same manner as any other Windows program open feature. The newest version of the software is able to open experiment file generated with the new software as well as past software releases.

Printing Experiment Data

To print experiment data directly from the software, click on File->Print. This will print the experiment data (right side) frame. To better control the print, use File->Print Setup and to preview the results before printing use File->Print Preview. A Print Preview is recommended before each print to ensure proper alignment on the page.

Copying/Enlarging Graphs

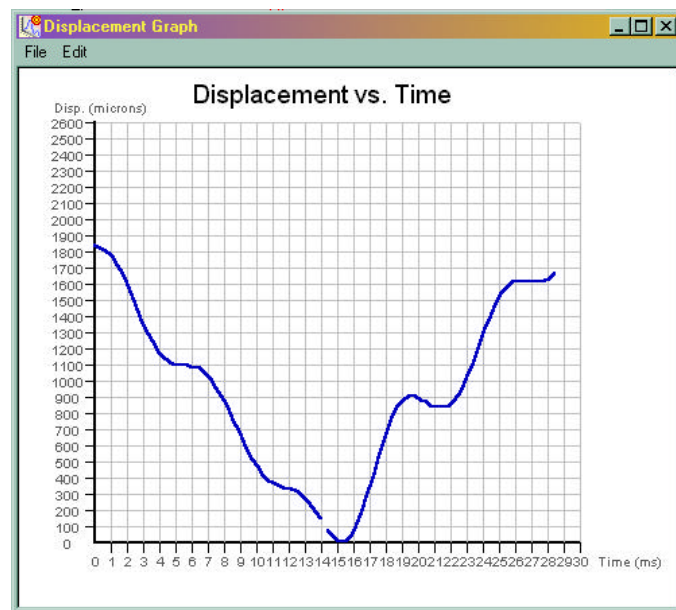


FIGURE 15 Displacement Graph Window

If the graph size is not large enough on the screen to be read with clarity, each graph may be opened in its own window. To do this, click on the View menu and click on either "Displacement Graph" or "Force Graph." This will display each graph in its own scaleable window (Figure 15). To enlarge or shrink the window, click and hold the left mouse button on the edge of the window and drag it to the desired size. From these individual windows, the graphs may also be copied out to be pasted into another program (WordPerfect, MS Word, MS Paint, or some other graphics program for example). To do this, resize the window to the desired size of the image when copied, then click the Edit menu and then "Copy." You may then use Edit->Paste to paste it back into the desired program.

Serial Port Settings

Currently, the default Serial Port settings are configured to properly work with the Control Unit. Altering serial port settings will cause the IH Impactor to stop responding. However, should the serial port settings need to be view or changed, they can be found by clicking on View->Serial Port Settings. If there is a problem with the IH Impactor, customer service may ask for these settings. There is also an interface to communicate directly with the Control Unit. This will never be used during an experiment. This is simply for customer services troubleshooting purposes. It can be accessed by clicking View->Serial Terminal.

Upgrading Firmware

From time to time, new improved versions of the firmware will be released via the PSI website. The firmware is the program that the control unit runs when conducting an experiment. This is permanently stored in the control unit and is typically never seen by the user. The software has the ability to reprogram the control unit should a new firmware version be released or the existing one need to be reinstalled. To do this click on File->Upgrade Firmware. An "Open File" window will appear. Find the firmware file (it has a **.hex** file extension). The current version of the firmware will be found in <Installation Directory>/Firmware where <Installation Directory> is typically "C:\Program Files\PSI\IH Impactor." When the firmware file is loaded, a progress bar will pop up and ask to begin upgrading firmware. Click "Yes" when ready. The upgrade typically takes a minute to load. During this time, the power must stay on to the control until and the serial cable from the computer to the control unit must remain plugged in. Any disruption will result in an incomplete copy and the process must be started again.

Care and Cleaning of the IH Impactor

The IH Impactor should be kept clean. Cleaning should be done with a damp lint-free cloth. Do not use an excessively damp cloth allowing liquid to drip onto the stepping motor or the position sensor. It is suggested that a light weight plastic cover be used to protect the instrument from dust and dirt when not in use.

The encoder strip that is used in the position sensor should **not** be cleaned or dismantled at any time during the cleaning process, since any disruption of the fine markings on this plastic strip will interfere with the precision of the stepping motor and positioning of the rack.

Once a year, depending upon the usage, a light weight silicon grease should be applied to the worm drives and gears utilized in the stage movement.

The Adson forceps should be removed from the adjustable armature and cleaned with a mild surgical cleaning solution. Care must be taken to avoid bending the delicate tips of the forceps. It is recommended that the forceps be removed from the instrument when not in use and placed in a safe location. Additional forceps may be purchased from the manufacturer.

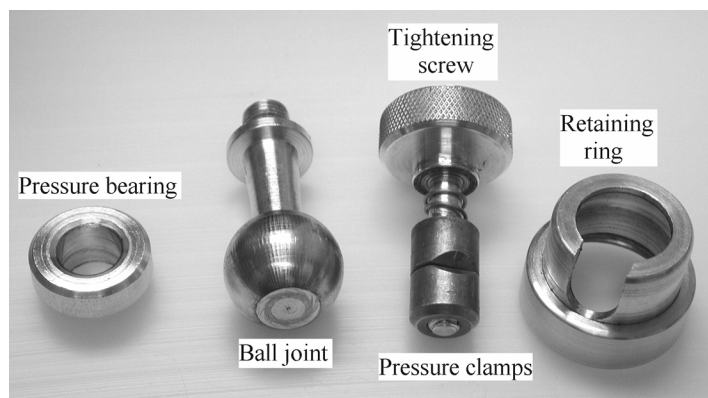
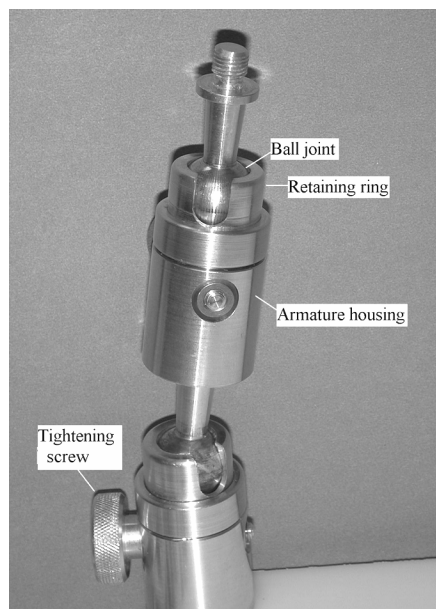


FIGURE 15 Assembled and Disassembled Support Arm.

The adjustable ball and socket armature may be disassembled after extensive use for cleaning. To disassemble the ball joint, unscrew the spring-loaded tightening screw immediately below the ball joint that is to be cleaned. This will release the pressure on the ball joint and allow the retaining ring to be removed.

With the retaining ring and spring-loaded tightening screw removed, the pressure bearing and two pressure clamps can be removed from the armature housing. The ball joint can be cleaned with 70% alcohol and a soft lint free cloth. Care should be taken to remove all dirt from the ball joint and to visually inspect the area for any foreign material that may harm the ball joint surface.

To reassemble the flex ball joint, first place the pressure clamps into the armature housing. It is extremely important that the small beveled portion of the clamps be visible from the top of the armature opening as shown in Figure 16. The pressure bearing can then be seated on top of these clamps. The ball joint is placed on top of the pressure bearing and the retaining ring is used to secure the ball joint in place. Finally the spring loaded tightening screw is placed into position. If the pressure bearing is seated properly, the ball joint can be secured into place by tightening the screw.

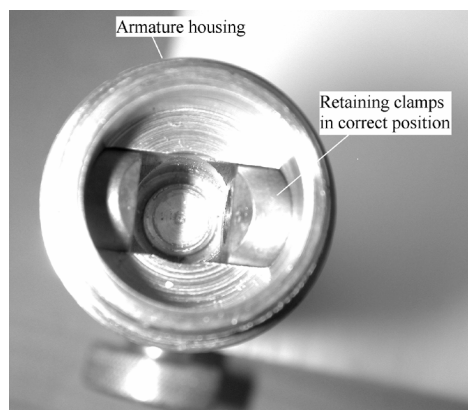


FIGURE 16 Armature Housing

If the ball joint does not appear to work properly after reassembly, remove the tightening screw, retaining ring and pressure bearing and realign the beveled portion of the pressure clamps and reassemble. Figure 16 shows the retaining clamps in the proper position as seen through the top of the armature housing with the retaining ring and pressure bearing removed. Note that the beveled portion of each retaining clamp faces the top of the armature housing. This is important for the proper seating of the pressure bearing during re-assembly of the unit.

Limited Warranty

What the Warranty Covers

We warrant the IH Impactor to be free from defects in material and workmanship for 90 days after shipment. Our obligation is to repair [or replace] our product if it should prove to be defective within 90 days of shipment. This warranty is void if the product is: (a) handled carelessly – including, but not limited to, failure to observe proper electro-static discharge precautions; (b) operated in excess of specified electrical or environmental limits; or (c) improperly calibrated by the user or a user-appointed third party. Note that we do not guarantee product suitability for all applications. Warranty policy is subject to change without notice.

How You Can Get Service

Warranty service can be obtained by notifying Infinite Horizon LLC in writing at the following address.

Precision Systems & Instrumentation
5221 Nottingham
Fairfax, VA 22032
Phone/Fax: (703)-978-2319